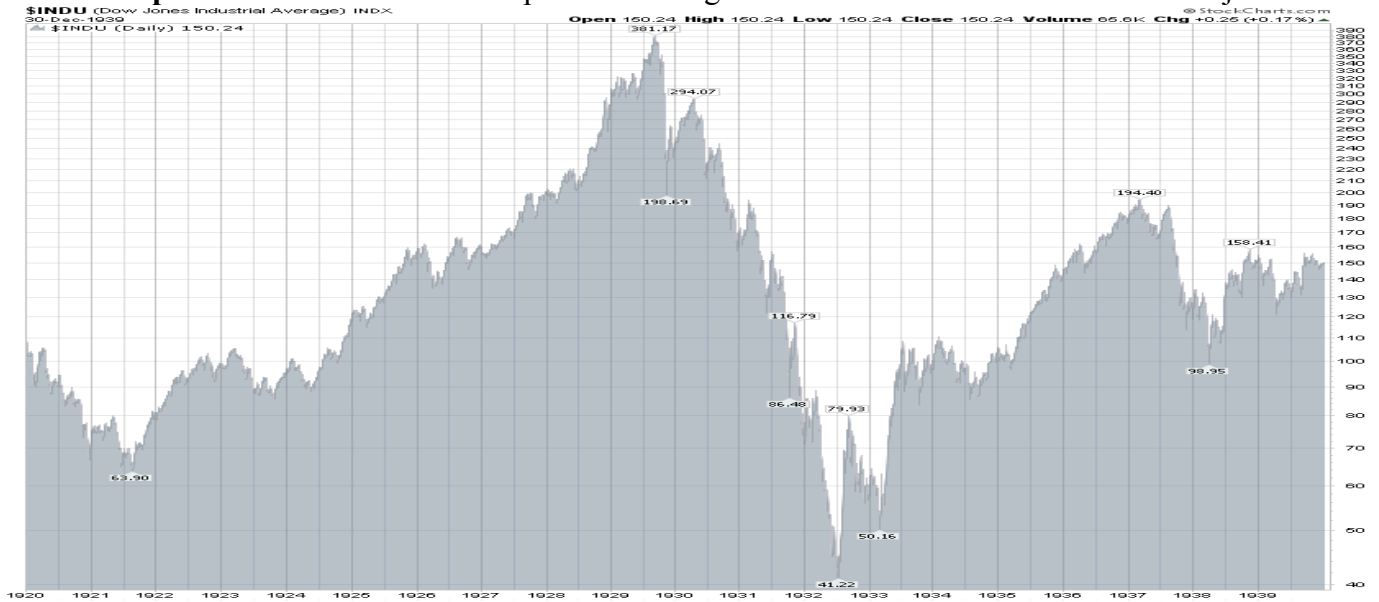
Lecture 1: WHAT IS DISCONTINUOUS CHANGE AND HOW DOES COURSE STUDY IT?

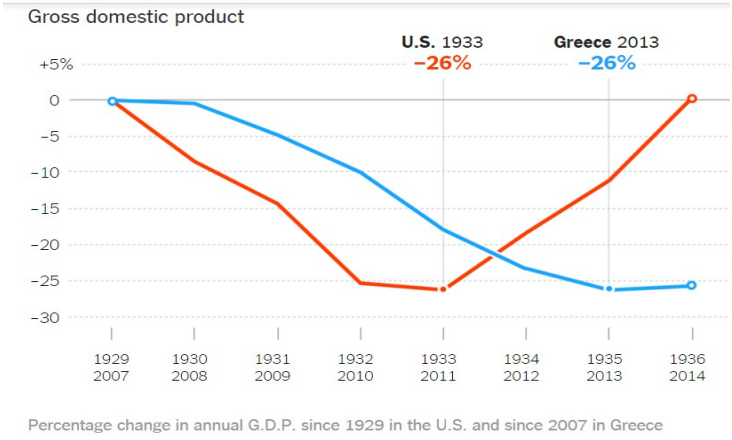
Discontinuous change is a sharp (but *fuzzy*) change that affects lives in important ways, as opposed to the marginal changes in prices and quantities that much of standard economics focuses on. It is the opposite of "Great Moderation", efficient market, stable economy thinking. Examples and charts illustrate:

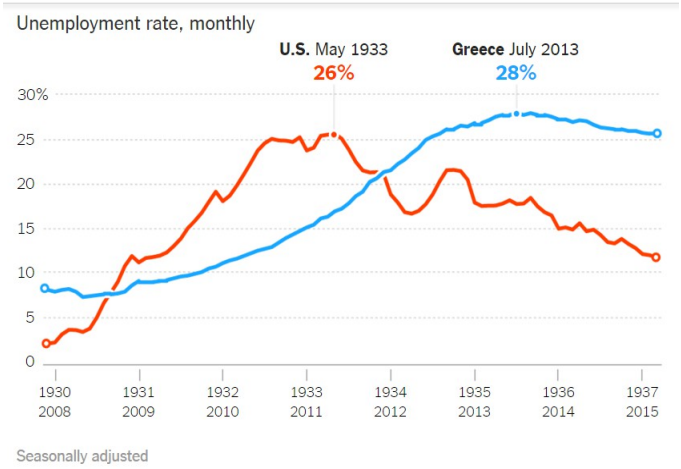
Great Depression(s); Natural disasters; Financial bubbles/collapses; Changes in social Institutions/behavior – fall of Soviet empire; union bursts; Crime waves and busts; Attitudes

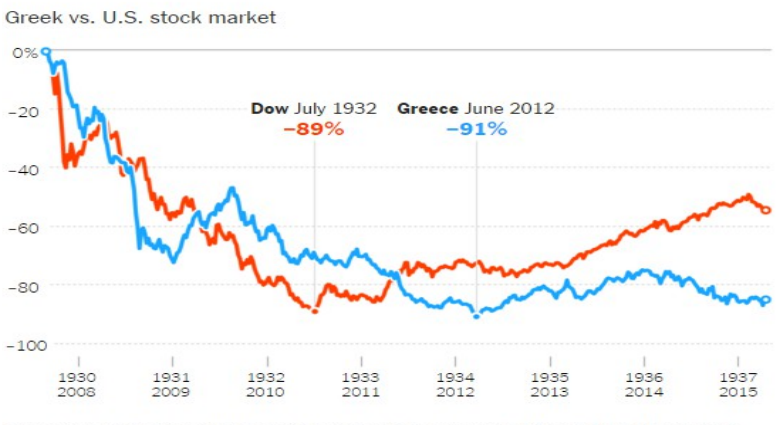
I. Great Depression: Stock market collapse: 381.17 high to 41.22 -89.2% and decade of mass joblessness.

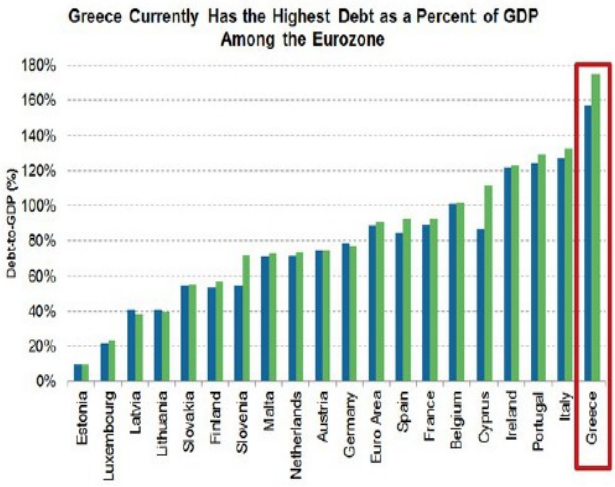


Greek Economist: "We are ahead of the US in one way: our drop in GDP exceeds the US Great Depression and has gone longer." Where will this lead?





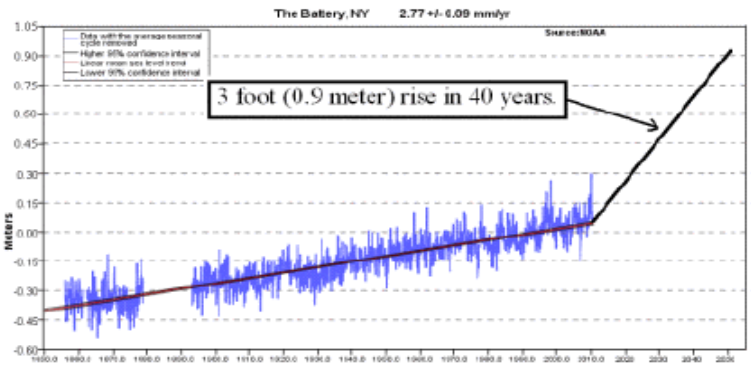




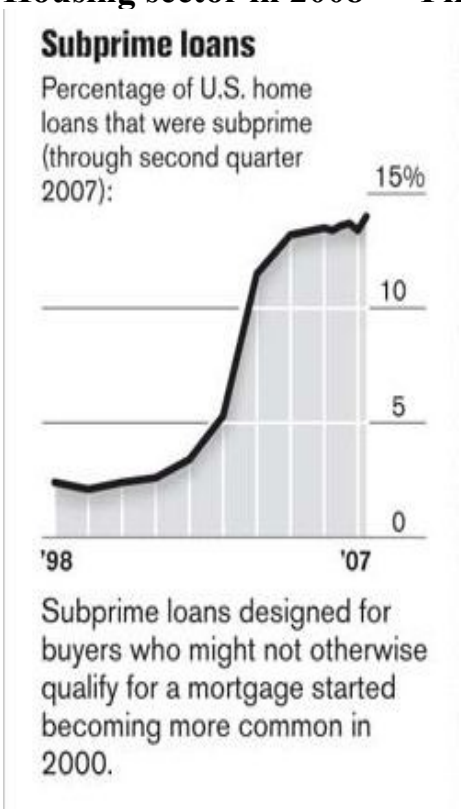
2 Natural Phenomenon: The Sky is Falling: the deadly threat posed by Near Earth Objects and what we can do about it (Rep. Dana Rohrabacher) Washington, July 21, 2008 - On June 14, 2002, the Earth narrowly avoided a deadly event.... which quite possibly would have had a devastating effect on the course of humankind. The close call came and went, and for three days nobody noticed that day a football field sized asteroid careening at 6.2 miles per second came within 75,000 miles of hitting the Earth. Three days later the asteroid was discovered, but of course by then it was far too late. Had the asteroid hit the Earth, the devastation may have equaled the 1908 Tunguska event, an asteroid or comet that flattened over 80 million trees in a remote region of Siberia. For stats http://neo.jpl.nasa.gov/risk/

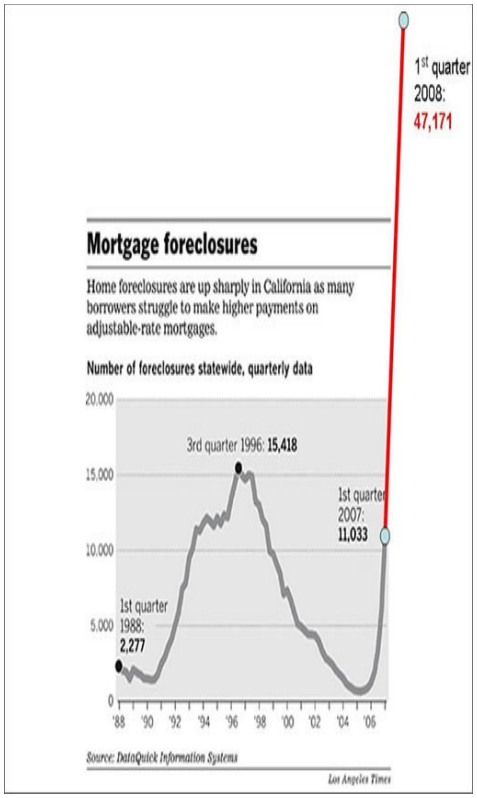
UPDATE: http://www.pbs.org/newshour/bb/science/july-dec13/asteroid_11-07.html
January 12, 2014. NASA Spots Dangerous Asteroid Heading for Earth

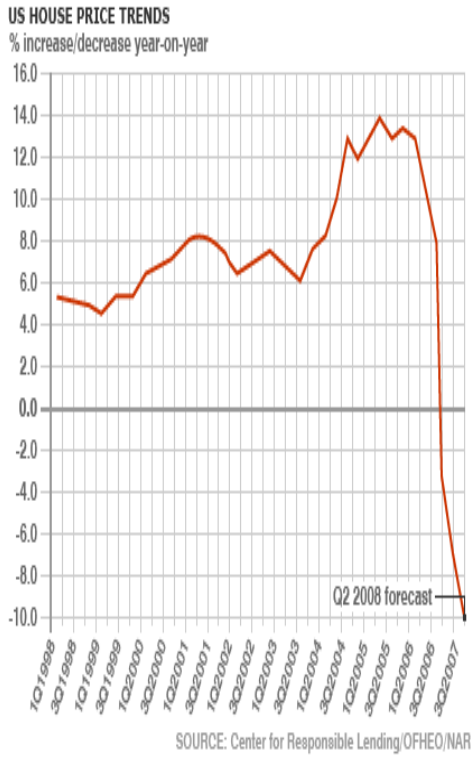
National Research Council (2002): Definition of Abrupt Climate Change --an abrupt climate change occurs when the climate system is forced to cross some **threshold**, triggering a transition to a new state at a rate determined by the climate system itself and faster than the cause. Chaotic processes … may allow the cause of such an abrupt climate change to be undetectably small …"**an abrupt change is one that takes place so rapidly and unexpectedly that human or natural system have difficulty adapting to it."** – sometime called tipping point, physics phase transition.



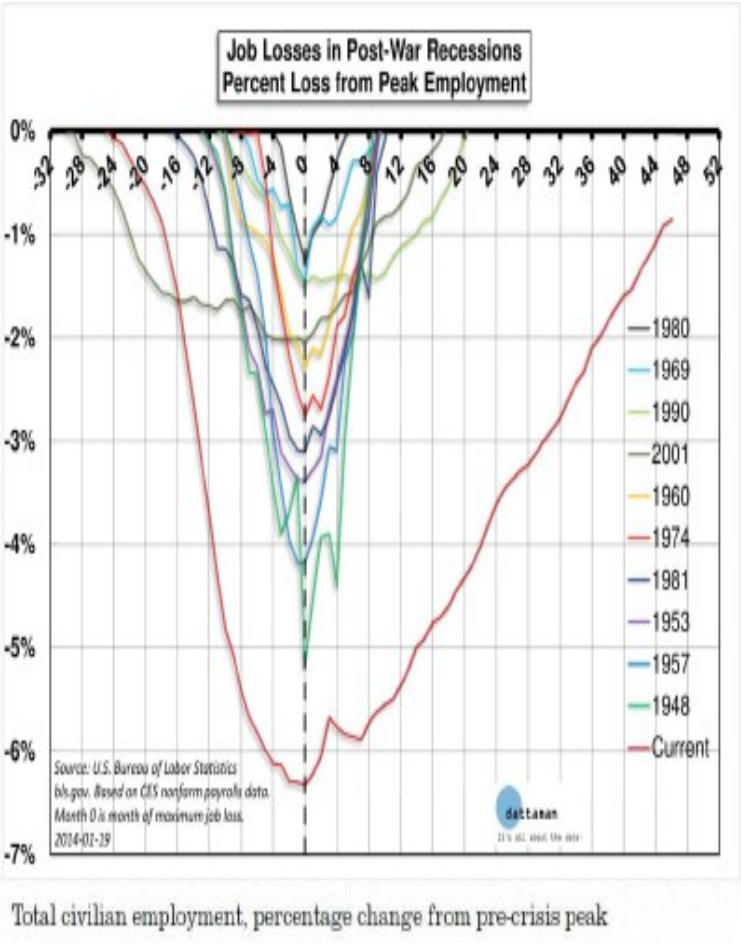
3. Achilles Heel/Squeaky Wheel of Capitalism – Banking system and bubbles. Housing sector in 2008 → Financial implosion →

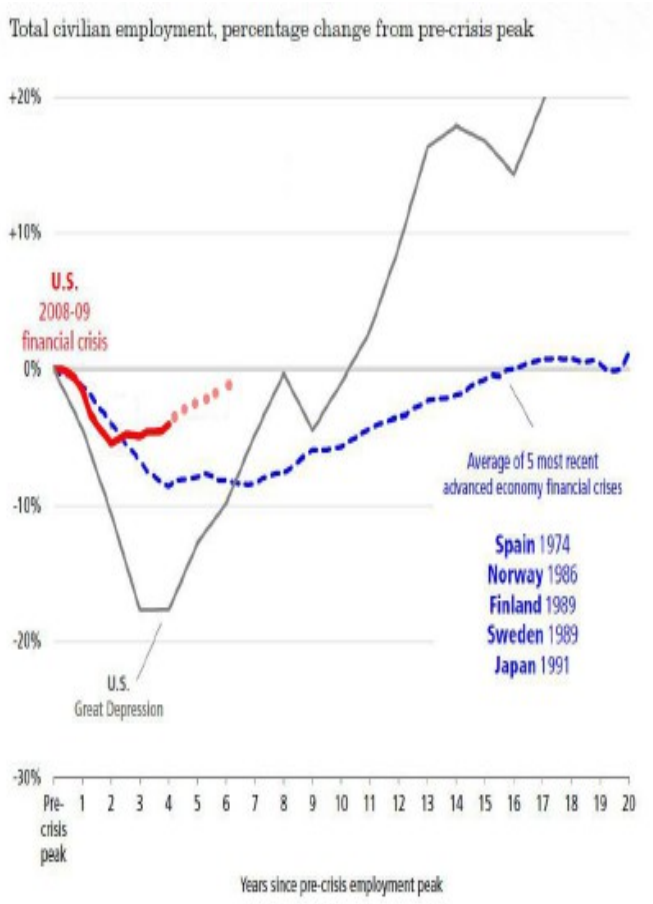






WORSE US JOB MARKET IN POSTWAR PERIOD **BUT THERE ARE WORSE**

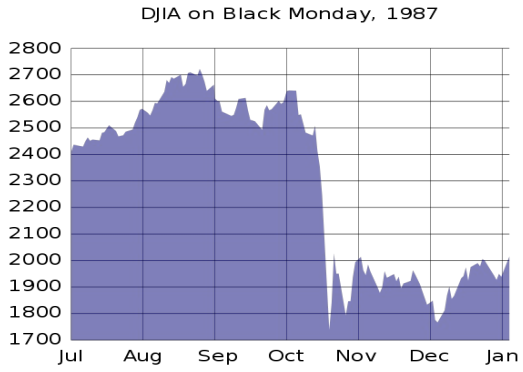




Post 2008 how much have we built in barriers to future speculative runs, bubbles, disasters? What are the odds of asteroid/bank crash that will devastate economy again?

But not all discontinuous financial changes → long term economic disasters

On October 19, 1987, Black Monday the Dow Jones fell from 2246 to 1738. The drop was 34 SDs off the normal variation in market prices. (From Economist, Oct 2012: TWENTY-FIVE years ago, on October 19th 1987, global stock markets suddenly, and unexpectedly, collapsed on what instantly became known as Black Monday. The Dow Jones Industrial Average fell by almost 23% in a single session, still a record decline.... Parallels with the 1929 crash, which preceded the Great Depression, were immediately made.



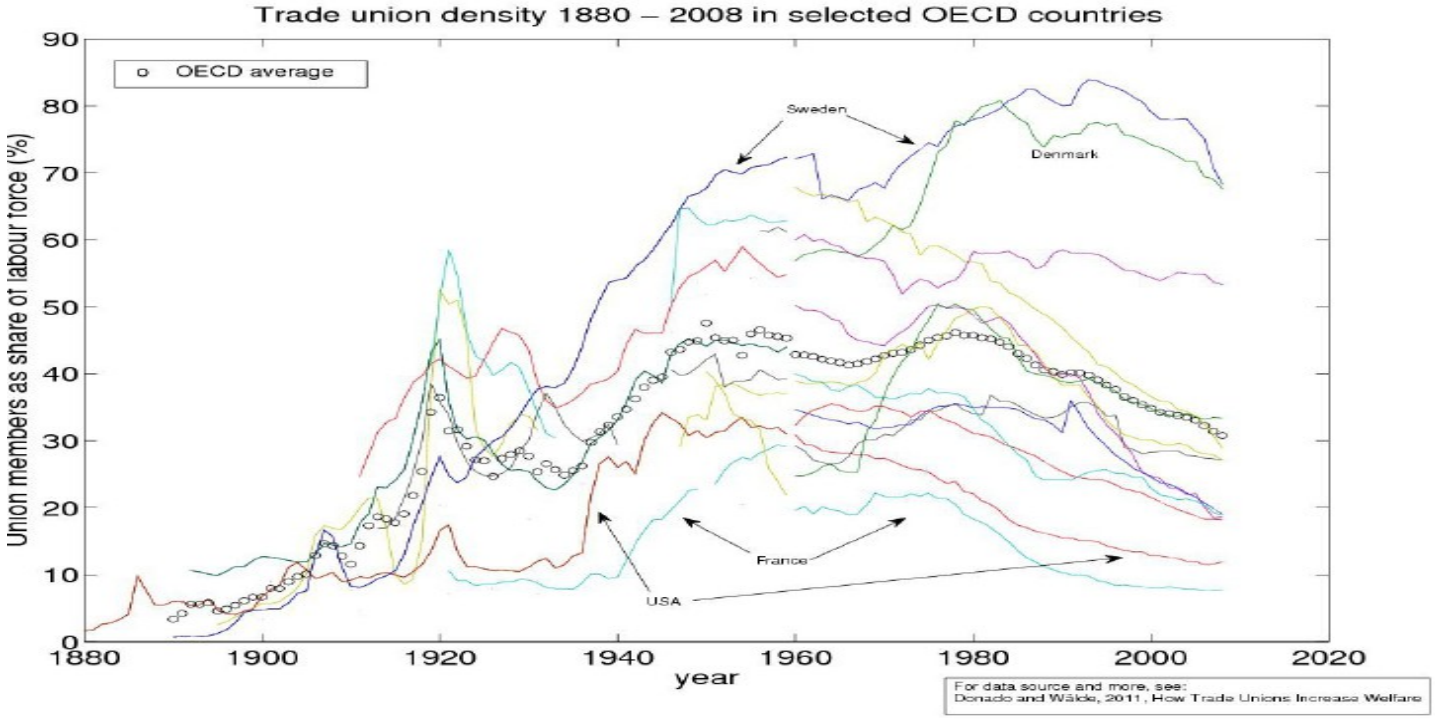
This was one of many financial crises that erupt regularly Sweden 1992, East Asian 1997, Mexico 1994 Russia 1998. Some turn into complete disaster, some just are unpleasant hiccups.

3. DISCONTINUOUS CHANGES IN INSTITUTIONS : Sudden surprising collapse of the Soviet Union (aka Evil Empire) between 1988 and 1991. Empire dissolves in 1989; USSR in 1991.

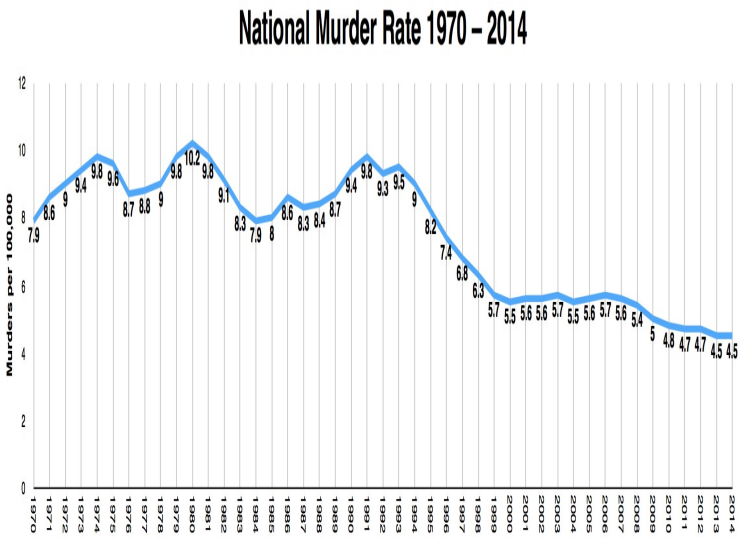
Few predicted collapse of communism. Many believed the Soviet system would converge gradually toward ours. Most economists thought when ex-Soviet became market-oriented, it would produce immediate gains in their economies. In fact most transition economies suffered 20%-30% losses before began to recover.

China did gradual changes and has done better, but still possible sharp change. Some analysts worry that Saudi monarchy may collapse. Other examples of **discontinuous regime change:** South Africa. The Shah in Iran ...the Suharto dictatorship in Indonesia. The collapse of Mayan society. Joseph Tainter's The Collapse of Complex Societies gives examples of discontinuous changes in societies. The Arab Spring revolutions.

UNION SPURT In 1930s. After Great Depression unions seemed dead as doornails. The President of the AEA, George Barnett, declared: "American trade unionism is slowly being limited in influence by changes which destroy the basis on which it is erected. ... I seen no reason to believe that American trade unionism will ... become in the next decade a more potent social influence." From mid-1930s to mid-1940s, unions grew massively. In the 1960s essentially no public sector workers were union; in a decade unionization jumped to 35-40%. This pattern of **spurt growth** occurs in other countries and for other social movements – living wage, anti sweatshop activity (ie 1995, few living wage campaigns; from 1995-present, over 100) – Occupy Wall Street that spreads worldwide. This cries out for a universal explanation.



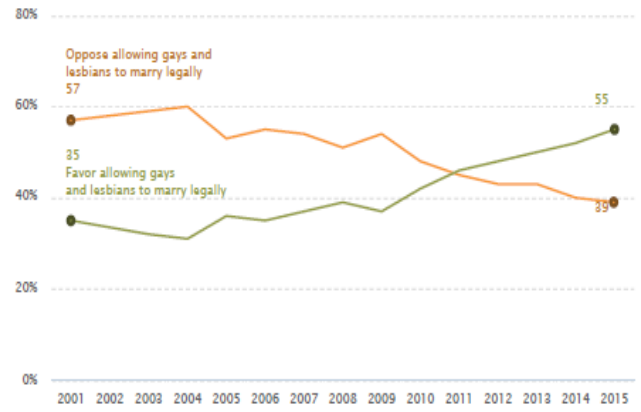
Crime/Social Pathologies. Parts of American cities have been social disaster areas, which seemed incurable a few years ago: half a million homeless; crime; children are brought up in fatherless homes with incomes below the poverty rate. Problems concentrated among blacks, but level of single parent families among blacks that shocked Moynihan in 1963 is the now the level among white. Wm Julius Wilson explains urban social pathologies in terms of the interconnections among migration, role models, and economics. Much to the surprise of most analysts, some problems – such as the rate of crime – have gotten better. NO ONE HAS A COMPLETELY CONVINCING STORY FOR RISE IN CRIME NOR FOR THE DROP except for Jessica Wolpaw Reyes- LEAD effects

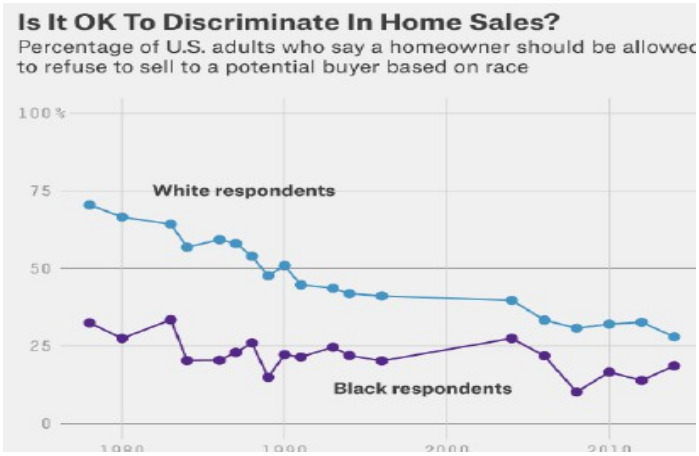


Rank by lowest rate	City	Population *2013 est.*	Total murders *Preliminary*	Rate per 100,000 2013	2014
1.	San Diego	1,355,896	32	2.9	2.4
2.	San Jose	998,537	32	3.9	3.2
3.	New York	8,405,837	333	4.0	4.0
4.	Los Angeles	3,884,307	260	6.5	6.7
5.	San Antonio	1,409,019	103	5.2	7.3
6.	Phoenix	1,513,367	116	8.3	7.7
7.	Dallas	1,257,676	116	11.4	9.2
8.	Houston	2,195,914	242	9.9	11.0
9.	Chicago	2,718,782	407	15.4	15.0
10.	Philadelphia	1,553,165	248	16.1	16.0

Where is? Boston 6/100,000; Detroit 46/ New Orleans 41/; Washington DC 16/ Source: FBI
http://www.neighborhoodscout.com/

Attitudes change over longer scale but still gigantic





HOW Economics 1881 DEALS WITH BIG CHANGES

We want to understand/ predict possible discontinuous changes to prevent/encourage them; to improve our ability to adjust to them in both short run and long term, and if we are future bankers/speculators/disaster profiteers/ marketeers/politicians how to make money/get votes from exploiting them.

Standard marginal economics ill suited to deal with big discontinuous changes. It is ceteris paribus analysis of marginal changes around equilibrium in prices, quantities, regulations – usually examined in linear model, whereas discontinuities involve non-linearities. Models of individual maximization treat the behavior of one agent independent of others. Assume individual has a smooth single peaked maximand with LOCAL OPTIMIUM that you find by differentiating/ hill-climbing. Market models shift one schedule and do comparative statics. Markets stabilize through negative feedback loops whereas big changes destabilize through positive feedback loops.

Experimental economics and behavioral economics well-suited for identifying behavior that does not follow rational optimizing models studying modest changes in behavior to incentives/information/etc but not at analyzing big changes.

Two big problems with analyzing big changes are :

1)BY DEFINITION THEY ARE EXTREME AND RARE EVENTS SO NOT MANY OBSERVATIONS. How do you learn and generalize from just a few examples when people/societies differ in many ways? What is the counter-factual to a rare event?

2)LOTS OF THINGS HAPPEN AT ONCE. The opposite of ceterus paribus – "mutatis mutandis"?, which refers to all the changes that happen in a legal transaction. But here meaning positive and negative feedback loops and interactions, income effects as well as substitution effects – a true dynamic general equilibrium.

Not only how you respond to price changes but how your neighbor responds to your response → run on bank, bubbles, riot in street. If you want to know how society responds to "Obamacare" need to know Congress, judiciary, political parties, state governments, medical insurance companies, unions, political parties … so final result of change may differ a lot from first order intended effect.

Course offers 4 types of tools:

1)Theoretical models: Focus of sections 1 on social interaction models and section 2 search strategies in evolutionary games. Interaction models lay out ways in which micro interactions among agents can produce surprising results and evolve in market settings. Search strategies focus on **rugged p**rofit or utility landscapes that have many optimum so local optimizing behavior is not enough. Must search for GLOBAL OPTIMUM

2)Macro modeling/empirics: Focus of section 3, which examines power law links frequency of events to magnitude; and network interactions/graph links that provide way to build macro-conclusions from individual interactions but generally take interactions/behavior/model as given or unknown black box.

After the Spring break

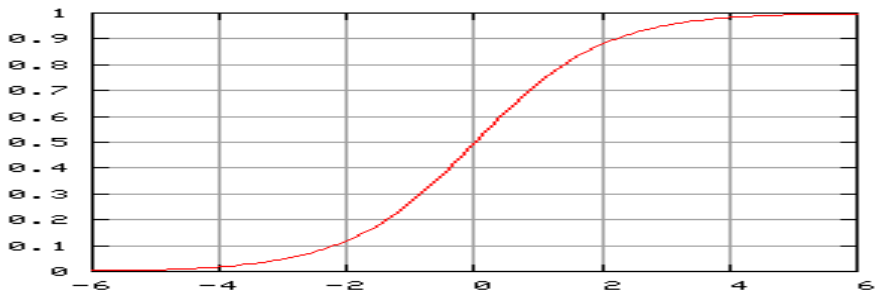
3)Use of Big Data statistics to assess non-linearities, illuminate behavior of units with specified characteristics and obtain parameters for simulation counter-factual models

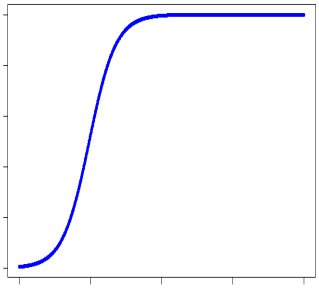
4) Simulation models. If you cannot experiment, simulate: systems dynamics – differential/difference equations to artificial agents. Key to any assessment of policy change is counter-factual – what would happen if we did/did not change X, so simulate counter-factual. But ideology can dominate counter-factual. "You think the Troika policy in Greece failed? Ah, but the Gods would have destroyed society far worse without the policy/".

Why discontinuous change is *fuzzy*

Because it does not mean discontinuity per math. Instead, signature is large derivative around some point. Often measured by *continuous nonlinear curve* to allow us to differentiate and get handle on rates of change

The most popular continuous curve to measure discontinuous change is **the logistic curve**. A one-parameter logistic is **P = 1/[1+ exp (-Bx)]**, which is valued between 0 and 1. It rises slowly then rapidly then slowly as it approaches its max. It is steeper when B is larger. When logistic is very steep, it is comparable to a threshold with a jump.





Virtue of the logistic is that you can differentiate while mimicking discontinuous jumps. "Sigmoids" of this form often arise from single peaked distributions. Given most single-peaked, you get a fast rise when you reach the peaked area, but only modest changes thereafter.

The derivative of the logistic is dP = B(1-P) P -- a parabola. At small or large P dP is small. Differentiate dP and you find that max dP is at P = 1/2. Note that with a simple transformation the logistic becomes

LINEAR LOG ODDS RATIO: ln(P/1-P) = -Bx.

If the maximum value is A, you have a two parameter logistic, P = A/[1+ exp (-Bx)], The logistic can depend on many xs: $P = 1/[1+ \exp (- \Sigma B_i x_i)]$.

Lots of phenomenon follow similar dynamics: a modest initial change, a sudden burst of rapid change, followed by slow movement toward the final value. Kauffman writes (p 57) "the rapid increase is the signature of something like a phase transition" – shift from one form to another. Logistic is used in neural nets and thus in "deep learning" computer algorithms**.**

Economic adjustment toward desired value implies logistic growth curves.

Assume some equilibrium, E* and that the firm/person adjusts by moving partway toward the equilibrium in a given period of time: dE/E = B (E*- E) so that you close B percent of the gap. This is a logistic, Write it as dE = B(E*-E) E and you can see that if scale E by E so that x = E/E*, then dE= B (E*-E)E –> dx/x= (BE*) (1-x) where the parameter in the logistic is BE*.

What generates discontinuities?

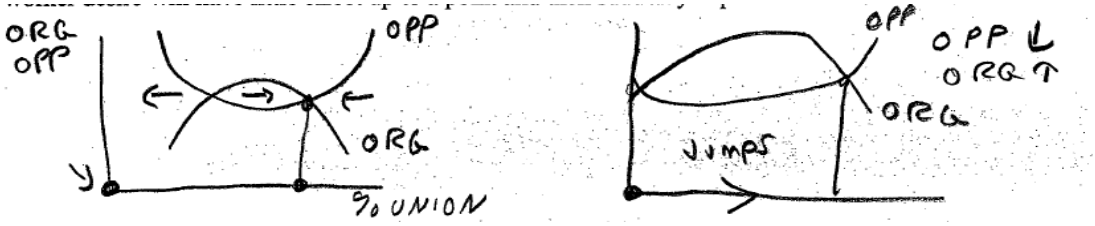
1)Non-linearities. Shifts in linear relations produce continuous changes. When linear (log-linear) supply and demand curves change, it induces modest changes along the other schedule. With the "right" kind of non-linearities you generate jumps; with critical parameter values and thresholds so that small differences can matter.

Consider the link between worker protests for unions and firm opposition to unions. The graph below uses two non-linear curves to represent how firms and unions behave at different %union rates: ORG which measures union resources for organizing and OPP, which represents firm resources to oppose union organizing.

The ORG curve shows that when % organized is low, unions have little organizing resources. If there are 10 members and 90 nonunion folk, the union will have to dun each member $10 to conduct an organizing campaign that costs $100. At higher density the cost of a campaign per member falls. If you have 20 members you raise the $100 with a $5 charge. When % organized is high, unions have little need to organize. This yields **NONLINEAR link between organizing effort and union density**, which we can write as a 2nd degree polynomial: $ORG = C + aU - bU^{2,}$

Similarly, we generate **non-linear link between firm opposition to unions and density.** When density is high, firms pay the going union wage/practices to convince workers to remain nonunion; they suffer no disadvantage from the "level playing field" unions establish. At low density, firms lose profits paying union wage compared to nonunion competitors. The link between opposition and density is nonlinear, say, a 2nd degree polynomial: $OPP = D - cU + dU^2$

Changes in density depend on the difference between the two: ORG-OPP. Unions grow when ORG-OPP s positive and decline otherwise.



The nonlinear reaction curves between density and behavior produce two equilibrium: high union (EU) and low union (US). When you perturb nonlinear reaction curves, you get jumps because it is in the interest of all people to shift from one state/behavior to another when others do. Notice the divergence in densities toward two equilibrium in the union figure: you can think of US as essentially 0 union point and the EU as high union point, where EU boosts unionism because many EU countries extend CB contracts from union/employer federation to all firms/workers.

2)**Positive feedbacks** can produce big jumps in behavior. I bump you. You bump me a bit harder. I bump back a bit harder … You punch me, I punch you.

Negative feedbacks -- changes in a variable reduce its magnitude usually lead to stable equilibrium.

3)Interactions among variables can also produce jumps. A positive interaction from X to Y and from Y to X can lead to an explosive growth while negative interactions can produce explosive decline.

When one variable has a negative impact on the other but the other variable has a positive impact on that variable, you can get oscillations. A classic system is the predator/prey model, which can be represented as:

(1) dP/P = - d + aH ,where P = Predator population which grows with prey H and has death rate d

(2) dH/H = b - cP, where prey H = Host population which declines with P and birth rate b

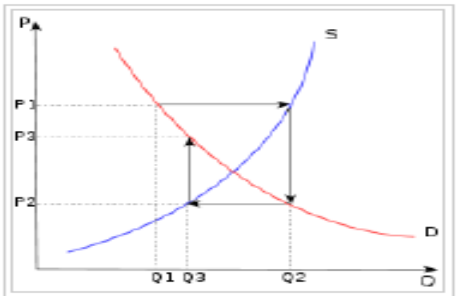
aH is interaction in 1: More hosts--> more parasites. -cP is interaction in 2: More parasites --> fewer hosts.

The negative feedbacks favor stability. If you start at equilibrium and add 5 Hs, this increases P (more food for the predator0 in equation 1, which then reduces H (equation 2). Similarly if you add to P, H falls,which reduces P. But the model **can** also generate fluctuations with wild swings of P and H. O**utcomes depend on parameter values.**

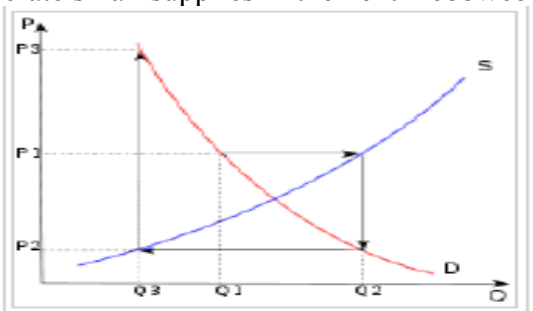
Cobweb model is classic economics example, arising from LAG between the price signal and supply response. The classic cobwebs are: agriculture, where the farmer decides to plant in year 0 and harvests a year later; labor market where students decide which field to study and graduate N years later. PhDs or MDs have long training lags.

CG = S + a W (-1) and W = X - e CG, where W=wage and CG = college graduates
S = exogenous shift in supply and X = exogenous shift in demand

Solve and we get a difference equation: CG = S + aX(-1) -ae CG(-1)
This implies that big supplies in one period generate small supplies in the next – cobweb fluctuations.



The *convergent* case: each new outcome is successively closer to the intersection of supply and demand.



The *divergent* case: each new outcome is successively further from the intersection of supply and demand.

This model postulates that CG depends on lagged wages, which agents assume will hold in future. Other expectations process –> other dynamics. Note that if everyone is same, total disaster … so need heterogeneity.

The Holy Grail of Policy Find a trigger or catalyst so that a small change moves the world from bad state A to better state B at little cost. For many problems, it may not exist, but for some, there may be such a solution through increasing returns, non-convexities, non-linearities, interactions, etc. Formal models clarify issues in public debate in ways that verbal discussion does not.